The Relation of the Municipality to the Water Supply

A SYMPOSIUM

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CHICAGO

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Chicago's earliest efforts to provide a satisfactory water supply for its citizens date back to November 10, 1834, when the board of trustees appropriated the sum of $95.50 for the digging of a large well, which was to supply the families adjacent and the community in case of fire. Owing to the inadequacy of wells as a source of supply, water carts were operated by private individuals, who sold lake water to the inhabitants at from five to ten cents a barrel. In January, 1836, the state legislature granted a charter for a period of seventy years to the Chicago Hydraulic Company, with authority to construct and operate a water works system in the infant city. The construction of the system, such as it was, was delayed for a period of four years, active operation not being effected before 1840. Water was obtained from an

intake pipe running into Lake Michigan about 150 feet and distributed through about two miles of wooden mains. Inasmuch as the area of the city at the time was about ten and one-half miles square, it is evident that but a small portion of the city was supplied with water by this concern. Four-fifths of the population was still supplied with water by wells and the crude cart system.

By a legislative act passed February 15, 1851, the Chicago City Hydraulic Company was incorporated as a part of the city government, and placed in charge of an elective board of water commissioners. Power was given the commissioners to purchase the tangible and intangible property rights of the Chicago Hydraulic Company, and to borrow $250,000 through a bond issue upon the credit of the city. Later additional power was granted the board to issue bonds for $150,000 and $100,000 in 1852 and 1854, respectively. The question of taking over the works of the old private company was submitted to the voters, 2,688 ballots being cast in favor of the purchase of the same by the city, while 513 electors voted negatively. The beginning of Chicago's municipalized water system may be said to date from this act of its citizens.

Work on a pumping station was begun, and a pumping engine with a daily capacity of 8,000,000 gallons installed. (It may be of interest to note that this engine, erected in 1853, was in continuous service until replaced by one of the modern high pressure pattern in 1904.) Water was secured through a 30-inch wooden inlet pipe extending 600 feet into the lake.

Operation of the new plant was commenced in February, 1854. It consisted of one reservoir, holding about 500,000 gallons, the pumping works and eight and three-quarter miles of iron pipe. During the first four months water was supplied but nine hours a day, and none on Sunday, except in cases of fire. Thereafter the supply was continuous throughout the twenty-four hours. The entire cost of the system up to December 31, 1854, was $393,045.32. The daily supply of water was 591,083 gallons during the first year. The average daily per capita pumpage was 8.9 gallons.

To meet the demands of the phenomenal increase of population and the rapid expansion of the city's area, the capacity of the water works required nearly constant augmentation. In 1858 a daily capacity of 20,000,000 gallons was thought sufficient to meet the requirements of a population of 84,000. In 1868 the capacity had been made 38,000,000 gallons, while the population had reached a quarter of a million. The total revenue at this time amounted to $420,686.00 as against a revenue of $102,179.00 in 1858. Where there were 72.4 miles of water pipe and 4,666 taps in the city in 1858, the year 1868 showed a total of 208.6 miles of pipe and 20,915 taps. In 1877 the capacity of the engines was further increased to 104,000,000 gallons, the population being 422,196. The number of taps was 59,369, of which 1,623 were metered. There were 424.6 miles of mains, and the revenue had reached $908,509.00. In 1889, by an addition of about 134 square miles to the city's area, making the population by 1892 nearly double that of 1888, it was necessary to give the water works system a capacity of 357,000,000 gallons to meet the new demand imposed upon it. The number of taps in 1892 was 203,954, while the miles of pipe in service was 1,402. The total revenue had become 2,738,434.10.

To-day Chicago's water supply is taken from Lake Michigan through five intake cribs situated from two to four miles in the lake and made accessible to the consumer through thirty-eight miles of tunnels and 2,075.50 miles of mains. There are ten pumping stations which pumped an average total of 436,954,473 gallons daily in 1906, or 204 gallons of water per capita each day. The number of taps in 1905 was 345,174, of which it is estimated that approximately 250,000 are in use. Twelve thousand three hundred and one meters were in service in 1906.

Owing to the vast amount of water wasted by the consumer through leaky mains and in various other ways, the problem of an adequate supply has become of serious and recurring importance to the city's engineers. The average daily per capita consumption has increased from forty-three gallons in 1860 to 204 gallons in 1906. To-day the pumpage per capita is five times greater than it was forty years ago. Although the present daily capacity is about 600,000,000 gallons, nevertheless, if the growth of the city be considered for the next ten years, the municipality will be forced to enlarge its plant over thirty-seven per cent within this decade. In the past ten years the average expenditure by the city in making needed extensions to its plant has been $700,000 annually, being for tunnels, pumping stations and machinery for pumping, exclusive of the distribution system. The city engineer advisedly estimates an average annual outlay of $600,000 for the next ten years as absolutely necessary in order to supply an expanse of territory which is taxing our pumping stations to the utmost.

It is evident that this strain upon our water works could be greatly abated by the prevention of unnecessary waste. Fully seventy-five per cent of all water pumped is wasted according to the city engineers. This waste is accomplished by reason of defective pipes and house plumbing, faucets left open to prevent freezing in winter and in summer to keep water and other matter cool. Mr. Joseph Medill Patterson, in a report made by him as commissioner of public works, on the subject of water waste and the manner of checking the same, said: "The only method yet known to stop waste is to install meters. And the necessity for installing meters cannot be over-emphasized. There are many things to be done to the Chicago water works in order to make it perfect. By far the most important and the easiest, the cheapest and the quickest thing to be done is to introduce extensive metering. When meters have been generally established and the waste reduced to a minimum we can unquestionably sell water to all consumers for five cents a thousand gallons, and not improbably for four and one-half cents a thousand."

In 1904 the amount of water pumped in gallons was 146,028,637,950, of which 21,717,046,000 gallons were pumped through meters. The revenue derived in this year from unmetered water was $2,218,076, while the sum of $1,616,464 was realized from metered taps. From this it is apparent that although only fifteen per cent of the total water pumped is registered through meters, forty-two per cent of the entire revenue received is from water sold through meters. Where the average revenue received for all water pumped was 2.628 cents per thousand gallons, the average revenue received from metered water was 7.44 cents per thousand gallons. While the cost to the city of 1,000 gallons of all

water pumped is 2.28 cents, it is selling unmetered water to the consumer at 2.25 cents per thousand, or .03 of a cent less than cost. Thus the desirability of placing the water works upon a business basis, equitable to the consumer and the city alike by the introduction of meters is palpable from the fact that the entire profit accruing to the municipality from the sale of water is from its metered water. As the average amount of water supplied through each unmetered tap is 430,000 gallons per year, it is argued that by extensive metering, after allowing a maximum per capita consumption of 100 gallons a day under meter control, the saving effected in water pumped would be 215,000 for each tap annually, which would mean a total saving of 2,150,000,000 gallons, or sufficient to meet the needs of an increase of population of 60,000.

By the installation of meters it is far from the purpose to make any restriction in the legitimate use of water. It must be clear that the buying and selling of water by measure is cheaper and more just than the present method. In lieu of a present daily per capita consumption of 204 gallons, metered service would easily reduce this to 100 gallons per day, due allowance being made for reasonable waste and leaks. A metering of but forty per cent of the taps in use means a saving to the municipality of at least $500,000 a year. Even though the installation be gradual at the rate of four per cent a year for a decade, the total pumpage at the end of this period would still be much less than it is to-day. Our water works system could be kept at its present capacity and maintain its present service without building additional tunnels and pumping stations. This is borne out by the experience of Milwaukee, where, the supply, being under meter control, no additional pumping machinery has been added for the last ten years, and the service is better than it was when the city first put in meters.

Water rates for taps not controlled by meters, are fixed according to a scale provided for by city ordinance. Such assessments are entirely dependent upon the frontage and height of buildings as well as the uses to which the same are put. These frontage rates are fixed upon a minimum basis. Extra charges are made for additional fixtures which involve the use of water for special purposes. All premises, where the frontage rates and charges for special fixtures aggregate $40.00 per annum or more, are subjected to meter control. A flat rate of seven cents per 1,000 gallons is charged metered consumers.

In considering Chicago's water supply from a sanitary point of view, one has but to revert to the time when the city discharged its sewage into the lake with the result that the source of the water supply at the intake cribs was polluted, and in consequence endangered the lives of its citizens. By the construction and opening of the sanitary and ship canal in 1900—also known as the drainage canal—part of the sewage was diverted from the lake to the canal, but not until the final completion of the huge system of intercepting sewers now being built, some of a width of twenty feet, will the danger of contaminating the water supply have been surmounted. These sewers are nearing completion in all parts of the city. Those in the southern division are now practically finished, while the partial completion of the north side system during the year will then entirely prevent the further flow of sewage into the

lake. This system of intercepting sewers, begun in 1898, and entailing an expenditure of $5,000,000, will, when completed, have been wholly paid for out of the net earnings of the water works.

The beneficent effect of the drainage canal in the purification of our water is abundantly proved by comparing the number of deaths from intestinal diseases, typhoid fever and such diseases whose origin can be laid to impure drinking water, for the two decades from 1885-1894 and 1895-1904. In the ten years from 1885-1894, typhoid fever caused 7,844 deaths, being a rate of 7.7 per 10,000 population, while in the decade from 1895-1904 there were 5,392 deaths, or a rate of 3.3 per 10,000, a reduction of fifty-one per cent. Where in 1891 the typhoid fever death rate was 17.38 per 10,000—being the highest of any city in the civilized world—the rate in 1905 was 1.65 per 10,000, or a reduction of ninety per cent.

Diarrheal diseases maintained a death rate of 25.6 per 10,000 population between 1885-1894, while from 1895-1904 the rate was 15.0, or a reduction of 41.4 per cent. This decrease in the number of deaths from intestinal diseases, Dr. Charles J. Whalen, until recently commissioner of health, attributes to: "Constant supervision of the water supply, with publicity of its daily condition; the regulation of lake dumping; securing sewage diversion from the lake; the correction of more than 100 local defects in tunnels and pumping stations in a single year; the promotion of the drainage canal and a vast amount of work for the sanitary district in the chemical and biologic examination of the streams between Chicago and St. Louis—are among the agencies which have reduced typhoid and diarrheal death rates—practically to the vanishing point for typhoid." Fully ninety-seven per cent of the water received from each of the ten pumping stations daily during 1906 was pronounced "safe" after being subjected to chemical analysis at the city laboratory.

The total cost of the water works system of Chicago from the date of its inception in 1854 up to December 31, 1906, is $42,156,989.19, the appraised net valuation of the entire plant at present being approximately $37,000,000. The amount realized in 1906 from assessed rates, metered service and miscellaneous earnings was $4,520,979.60, being an increase over 1905 of $301,417.16. The total cost of maintenance in 1906 was $2,060,249.12, an increase of $12,853.99 over 1905.

During the past year a number of pumping stations were equipped with modern pumps and boilers. A number of improvements are now under way, such as the construction of new tunnels, pumping machinery and boilers. Chief among these is a land tunnel, ten miles in length and varying from nine to fourteen feet in diameter, which is considered the largest of its kind in the United States. It will be 120 feet below the level of the lake and of sufficient size to supply three pumping stations of a daily capacity of 100,000,000 gallons each.

In accordance with a broad and ascertained plan all pumping centers are being provided with a capacity of 100,000,000 gallons daily each and placed about six miles apart. This will render it necessary to force water through pipes over an area not greater than three miles in either direction, thereby

vastly improving the local water pressure and causing a saving in the cost of pumpage on account of the low friction heads obtained in the water mains. It may be stated here that the total cost of pumping 1,000,000 gallons of water one foot high in 1906 was $3.89 against $4.25 in 1905.

Extensive coal testing experiments were conducted in 1906 and notwithstanding the increased quantity of water pumped during the year a saving of $43,214.91 was effected in the city's coal bill. By an ordinance of the city council the city engineer has been given complete control and sole responsibility of the water works. Where formerly the property owner under meter service was forced to install a meter on his premises at his own expense, the city council has relieved him of the burden and placed it upon the city. In pursuance of a general progressive policy the water department has installed an entirely new system of accounting constructed along the lines of the most approved railroad accounting.

With the general metering of taps achieved in the near future, and its consequent happy effect upon the water works system from a financial and an engineering point of view, Chicago can then point with pride to a municipal water plant first in the purity and health sustaining qualities of its product, in the reasonableness of its rates and in its general freedom from misgovernment and corruption.

PHILADELPHIA

By Henry Ralph Ringe, Philadelphia.

The City of Philadelphia is particularly indebted to its founders for their wisdom in selecting a site at the confluence of two large rivers, the Delaware and Schuylkill, where there is running water in abundance, and the drainage is excellent. The early settlers depended upon wells and springs, but as population increased these sources were polluted, and it became necessary to devise some method whereby the pure water could be brought into the city.

This most important question of pure water was aroused in the public mind by Benjamin Franklin, who deserves much credit for presenting the most feasible and least expensive plan for water works. It was Franklin's plan to bring the water of the Wissahickon Creek to the city by gravity—this recommendation appeared in his will of 1789. Had he not died in 1790 this project would have been consummated, and the great yellow fever epidemic of 1793 would probably have been averted.

It was not until 1797 that the first petition for the introduction of pure water into the city was presented to councils. After much discussion and the presentation of many schemes, Benjamin H. Latrobe was appointed, in 1798, to investigate the entire subject. In the latter part of the same year Latrobe presented his report, and declared in favor of the Schuylkill River, because of its "uncommon purity," and summarized the proposed schemes as follows:

1. To complete a canal immediately which would run through the city

and from which the water might be drawn through pipes into private cisterns in the cellars of the houses.

2. To carry out Franklin's plan of conducting the water of the Wissahickon to the city. (Had this been carried out the city would have had a daily supply of about 60,000,000 gallons, a quantity not required until 1880.)

3. To erect water works to be driven by one of the two rivers.

4. To collect water in impounding reservoirs from any practicable source, and thence conduct it in wooden or iron pipes to the city.

5. To construct a reservoir in Center Square (the site of the present Public Buildings) with an elevation of forty feet, at an estimated cost of $75,000.

Due consideration having been given his plans, they were finally adopted and the first water works were accordingly erected and operated by steam at Chestnut Street wharf, on the Schuylkill, and at Center Square, with Latrobe in charge of the building. To meet an inadequacy of funds, councils authorized a loan of $150,000, all subscribers to which received three years' supply without charge from the date of initial operation in 1801. The two steam engines installed were the first and largest pumping engines in the United States, having a capacity of raising 3,000,000 gallons fifty feet high in a day.

The cost of running the engines, the trouble of keeping them in repair, and the uncertain supply of water led councils, in 1811, to direct the "Watering Committee" to make another examination and inquire into a better method of supplying the city. They reported after a short time in favor of a steam works at Fairmount. These works were immediately begun, and turned over to the city in 1815, the Center Square works then being discontinued.

Up to this time the city was receiving no direct pecuniary benefit from the water works, in fact a sufficient amount was not realized from water rents in any one year to pay for the fuel and running of the engines. The cost of the Schuylkill and Center Square works, with yearly expenses from March, 1799, to September, 1815, was $657,398.91, while the entire gross receipts were but $105,351.18, leaving a deficit of $552,047.73, without interest. The new works erected at Fairmount were also expensive, and as the population was very rapidly increasing great difficulty was experienced in maintaining a sufficient supply. The problem was ultimately solved in 1818, when the city purchased the dam and locks at the Falls of Schuylkill and in the next year commenced a dam 1,600 feet long across the Schuylkill River at Fairmount in place of the steam works, which were abandoned at the completion of the dam in 1822.

The completion of these works marks the beginning of the present water supply system of the city, and although the subsequent works were run by steam, as is shown in the following table illustrating the growth of the system, the Fairmount works are still running, with the one variation of having turbine wheels in place of the old wooden breast wheels.

Pumping Station.	When Started.	How Operated.	Daily Average in Gallons Pumped.				Aggregate Capacity in Gallons per day. 1905.
			1855.	1875.	1895.	1905.	
Fairmount	1822	Water	7,611,756	23,833,072	20,786,830	19,265,734	33,290,000
Spring Garden	1845	Steam	4,178,096	5,641,688	138,915,593	129,091,769	170,000,000
Delaware and Frankford	1851	Steam	1,556,197	2,214,340	12,911,930	36,852,752	117,000,000
Twenty-fourth Ward Works*	1855	Steam	103,606	.....	.....	.....	.....
Belmont	1870	Steam	.....	8,371,254	23,116,379	43,572,768	65,500,000
Germantown†	1851	Steam	.....	.....	.....	.....	.....
Roxborough	1872	Steam	.....	2,487,354	17,029,941	26,494,369	35,500,000
Chestnut Hill	1873	Steam	.....	92,033	82,824	2,246	750,000
Mount Airy	1887	Steam	.....	.....	1,595,825	44,018	3,000,000
Queen Lane	1895	Steam	.....	.....	359,276	72,075,051	80,000,000
Belmont Auxiliary	1895	Steam	.....	.....	160,319	2,277,779	7,000,000
Roxborough Auxiliary	1895	Steam	.....	.....	865,322	13,148,278	40,000,000
Frankford Auxiliary	1900	Steam	.....	.....	.....	647,804	7,000,000
Total	.....	.....	13,449,655	42,639,741	215,824,239	9,343,472,568	559,040,000

* Abandoned in 1870 at completion of Belmont Works.

† Private concern; came into hands of city 1866. Abandoned in 1872 at completion of Roxborough Works.

The number of reservoirs has increased in proportion to the growth in the demand for an increased water supply, as the following illustrates:

Date.	No. of Reservoirs.	Capacity in Gallons.
1875	9	123,783,000
1890	11	848,447,000
1905	21	1,548,397,000

The relative increase in the quantity of water used has been as follows:

Date.	Total Amount of Water Pumped into Reservoirs. Gals.	Average Daily Consumption. Gals.	Average Daily Consumption per capita. Gals.
1875	15,097,160,069	47,639,741	56
1890	51,698,508,699	141,639,749	132
1905	125,367,447,176	326,630,253	227.2

The supply at present is quite adequate, the pumping stations having a total daily capacity of 559,040,000 gallons, whereas the average daily pumpage is only 343,472,567 gallons, or over 200,000,000 gallons less than the present capacity of the pumps.

The charges to the consumers are in the form of water rents, which are regulated by the city councils, who establish a minimum rate proportionate to the size of the connection to the main. The water rents are paid to the city treasury. As a usual thing dwelling houses have but one water attachment, while stores, office buildings and manufacturing establishments may have more than one connection when necessary, it being provided that the amount of annual water rent by schedule rates for every ferrule connection charged to any person shall not be less than certain specified minimum rates, which are:

½-inch ferrule	$5.00
¾-inch ferrule	26.00
1-inch ferrule	40.00
2-inch ferrule	160.00
4-inch ferrule	640.00
6-inch ferrule	1,440.00

The use of the water meter has not been very successful. Meters do not work equitably, and are merely optional with the consumer. In 1905 there were but 1,735 meters in use in manufacturing plants, a decrease of 28 from the preceding year. These are only installed when formally requested by the owner of any premises not a private dwelling, where there is an excess of water used beyond that charged for by the fixture or ferrule rate. No meter can be removed without notice to the bureau. Those violating this rule are charged by meter rates for the entire ensuing year. The rate to all places not charitable institutions is 30 cents per 1,000 cubic feet.

The minimum meter rates are:

½-inch ferrule	$5.00
¾-inch ferrule	13.00
1-inch ferrule	20.00
2-inch ferrule	80.00
4-inch ferrule	320.00
6-inch ferrule	720.00

Charitable institutions are charged 4½ cents per 1,000 cubic feet. All the meters are the property of the city, and no rental is charged unless the meter is unduly damaged.

The earnings of the bureau of water have been materially increased since the adoption of the present system in 1822. For the year of 1905 the total receipts were $3,790,447.26 and the total expenditures were $1,746,025.71, of which $945,389.16 were for current expenses and $800,636.55 were for extensions and improvements, leaving a profit of $2,044,421.55 for the year 1905. The net earning of the bureau since the installation of the works in 1799 to December 1, 1905—was $91,232,768.65. The total expenditures for maintenance and construction, improvements, etc., for the same period were $72,213,364.19, making a net profit since 1799 of $19,019,404.46.

Adequate as the facilities have been the water supply has not been of the best up to the last few years owing to the great pollution of the Schuylkill River before it reaches this city, and as a consequence much typhoid fever has resulted. This, however, is slowly being eradicated by the great filtration system which has been in process of construction since 1898. This system, when completed, will unquestionably be the greatest of its kind in existence, and although politics have very unfortunately entered into the work to such an extent that all work was stopped for one year pending a political investigation, still, the time of completion is within sight. The work of Major Cassius E. Gillette, U. S. A., and the others in charge will be a lasting monument to their skill and patience in time of difficulty.

Up to 1905 there has been $22,500,000 appropriated from loans and direct taxation for the impovement, extension and filtration of the water supply, and it is estimated that before final completion it will cost at least $30,000,000.

The four filtration plants and their respective capacities are as follows:

Section.	Estimated Capacity of Filtered Water when Completed—gals.	Daily Average in 1905 of Filtered Water —gals.	Cost per 1,000,000 Gallons in 1905.	Water taken from	Started.
Lower Roxborough...	12,000,000	9,627,000	$3.69	Schuylkill.	1903
Upper Roxborough..	20,000,000	10,096,000	4.56	Schuylkill.	1903
Belmont	40,000,000	26,252,000	4.13	Schuylkill.	1904
Torresdale	248,000,000	.....	.....	Delaware.	.....
Average	.....	45,975,000	$4.13	.....	.....

Together with these there are the Shawmont and Lardners' Point pumping stations, the former of which is connected with the Roxborough filters and the latter with the Torresdale filter. At the Torresdale station, unless some unforeseen condition arises, there will be filtered a volume of water larger than the entire consumption of London and two and one-half times the combined capacity of the filtration work at Berlin and Hamburg. It will supply a population of nearly 1,100,000, and will represent nearly five-sixths of the entire water supply of the city. At present only West Philadelphia, Germantown, Chestnut Hill, and Manayunk are supplied with filtered water, the daily average quantity of filtered water being 45,975,000 gallons, which cost $4.13 per million gallons.

The effect of this filtered water upon these sections of the city in comparison with the sections which use unfiltered water, in regard to the elimination of typhoid fever, is very noticeable, as is illustrated in the following table compiled by the filtration bureau in 1905:

Locality.	Population.	Cases.	Per 100,000
City of Philadelphia	1,491,247	6,451	8.32
[1]21st and 22d Wards (filtered)..	113,755	192	3.51
28th and 38th Wards (unfiltered)	89,142	289	6.74
West Philadelphia (unfiltered).	181,941	562	6.05
Wards, 23, 25, 33, 35 (unfiltered)	144,968	2,105	27.59
Filtered water district in West Philadelphia	41,424	215	0.71

The works at present are in a generally satisfactory condition, but owing to the rapidly increasing population in certain sections of the city, it is almost impossible for the supply to keep pace with the demand. Many improvements already contemplated, such as new pumping stations, engines and boiler houses and large distributing mains are being delayed because of the lack of sufficient appropriations, but in spite of these hindrances it is an agreed fact that when these various improvements have been completed the localities suffering from an inadequate supply and pressure will be relieved and the City of Philadelphia will enjoy the benefits of a splendid system.

BALTIMORE

By Henry Jones Ford, Baltimore, Md.

The water supply of Baltimore City is owned and operated by the city government. The department is managed by a board of five commissioners, appointed by the mayor and confirmed by the second branch of the city council, as in the case of other municipal appointments. The president of the board is the water engineer, who is a salaried officer. The remaining

[1] The average in the Twenty-first and Twenty- second wards may seem a little high, but this is due to the fact that many of the people residing in this section are occupied during the day in other portions of the city which receive unfiltered water.

members of the board are unpaid, this being the usual manner in which the executive commissions in Baltimore administration are constituted.

The city water department dates back to the appointment in 1852 of commissioners to acquire water rights belonging to the Baltimore Water Company and others. A 6 per cent loan of $1,350,000 was issued for the purpose, and with that investment the public service was organized. The water board was organized under an ordinance passed in 1854. With the growth of the city the service has gradually enlarged and extended. At present there are two sources of supply: Gunpowder River, with an average daily flow of 710,000,000 gallons, and Jones' Falls, 35,000,000 gallons. There are two impounding reservoirs: Loch Raven, on Gunpowder River, and Lake Roland, on Jones' Falls, having a capacity respectively of 410,000,000 and 400,000,000 gallons. In addition there are seven storage reservoirs, with an aggregate capacity of 1,328,875,000 gallons. In 1906 the daily average of consumption was 66,863,925 gallons, a per capita of 119 gallons.

Water meters may be introduced as the water board considers it expedient. During the last seven years 2,711 new meters have been put in service and meter revenues have increased from $206,844 a year to $318,377 in 1906. The law authorizes the board to meter certain classes of property in which consumption is likely to be large, and consumers avoid meters if possible, as license charges are low and meter charges are almost invariably heavier. The flat rate on dwelling houses is only $2.50 a year for a house not exceeding 12 feet front; $4.00 over 12 but not over 13 feet; $5.00 not over 14, and so on. On an 18-foot front house the charge is $12.00, and on a 25-foot front $17.00. There is no extra charge for dwelling houses except for closets, $2.00, and urinals, $1.50. No charge is made for bathtubs in private dwellings. There is a list of special charges applying to business establishments and for the use of water motors, etc. By meter the rate is 45 cents per 1,000 cubic feet ordinarily, but is 60 cents for hydraulic elevators.

The supply comes to the city by gravity flow, but there are high service reservoirs for which pumping stations are maintained. The purity of the supply is guarded by vigilant inspection of the water shed, but it has not been found necessary to resort to filtration. The ample supply of clear water kept in storage is sufficient to provide pure drinking water.

The area of Baltimore prior to 1888 was 13.202 square miles. By annexations made in that year an area of 16.939 square miles was added, and service to the new districts will require extensions that the water board is now planning to carry out at an outlay of about $5,000,000, for which bonds will be issued. Larger impounding capacity will be required on the Gunpowder River, as while the average daily flow of that river was over 263,000,000 gallons in excess of the average daily consumption, yet there have been times when the daily flow was less than the maximum daily consumption. The water shed is, however, adequate to all requirements now calculable, and the continuance of the present policy of steady improvement seems all that is required by the situation.

The receipts in 1906 were $961,630, and the expenditures were $928,813, leaving a surplus of $32,816, which, in accordance with the governmental sys-

tem here, was turned over to the Commissioners of Finance as an unexpended balance. The statement of assets and liabilities to December 31, 1906, shows total assets of $16,818,094, against which were liabilities amounting to $9,539,616, of which $9,500,000 were for water loans. The Baltimore water department supplies water at low rates to consumers, and it is managed with a view to public service rather than earning profits. Indeed, it is stated that the annual surplus is only nominal, and all that is really sought is that the department shall pay its way.

CLEVELAND

By EDWARD W. BEMIS, Superintendent City Water Department, Cleveland, O.

The necessary brevity of this article forbids a full account of the history and present conditions of the Cleveland water works, but a few facts may be of interest. The city began pumping water through the plant that it constructed itself in the year 1856, and has continued to operate the plant ever since. Prior to that time there were no water works in the city, and attempts had been made by the city government to induce a private company to undertake the work, but the inducements had not been considered sufficient.

The following table will give some idea of the growth of the department:

Year.	Connections in use.	Gallons of water pumped.	Meters in use.	Net receipts from water.
1870	3,893	1,126,228,500	.....	$70,411.18
1880	10,013	3,725,683,021	402	202,377.92
1890	30,938	10,142,312,796	1,794	502,954.11
1900	53,473	24,487,098,808	2,810	765,511.95
1906	67,519	21,552,886,258	56,168	848,746.87

The supply is taken from Lake Erie through a tunnel nine feet in interior diameter and five miles in length, extending out to a steel crib four miles in a direct line from the shore. This tunnel has a capacity of over twice the present maximum daily pumpage. The new pumping station has a daily capacity of 110,000,000 gallons, while the maximum consumption is only 80,000,000 gallons, and the average is only 59,000,000 gallons. Reservoirs with a capacity exceeding the maximum daily consumption equalize the pressure and are a still farther safeguard to the city.

The charge for water to all consumers, large and small, is very low, being 5 1-3 cents per 1,000 gallons, which is the same as 40 cents per 1,000 feet. This is a lower rate than any private water company charges, and for the ordinary house consumers is a lower rate than any municipal plant, with possibly one or two exceptions. In fact, those possible exceptions probably do not exist if account is taken of the fact that to enjoy the low meter rates in these two or three other cities, the consumer must purchase and set

his own meter, while in Cleveland that expense is entirely borne by the water department.

Three-fourths of the houses that are metered pay a minimum of $5 a year, and the other one-fourth pay a minimum of $2.50. Over half of all the residences and tenement houses in the city averaged for the six months ending in April, 1907, only $2.48 per building or service connection.

With the introduction of meters, everyone was given the wholesale rate above mentioned of 5 1-3 cents per 1,000 gallons, which had hitherto been given to only a few hundred besides the large consumers, practically no others being metered. The reduction given to the 51,700 buildings or service connections that had been metered since 1900 amounted in April, 1907, to 40.56 per cent below what had been paid on the assessment or flat rate basis. This has meant a reduction of about $200,000 a year in the revenue of the department below what it would have been without meters. It would not have been possible for the department to have stood this loss in its revenue had not the introduction of meters checked the rapidly growing increase of waste and of expenses which had previously prevailed.

The pumpage had increased during the six years, 1888 to 1894, from 8,491,091,152 gallons to 14,414,534,830 gallons, or about 70 per cent. The increase from 1894 to 1900 was 10,072,563,978 gallons, or again 70 per cent, while there has been an actual decline in the annual pumpage during the last six years of 2,934,212,550 gallons, or 12 per cent. In none of these cases is allowance made for slip of the pumps, which would not materially affect the general conclusion.

In spite of the reduction in pumpage, there was so great an increase in the population of the city and in the number of consumers, the latter increase being over 26 per cent, that the operating expenses and ordinary repairs increased 12 per cent from 1900 to 1906. This, however, was small compared with the increase of 60 per cent in such expenses from 1888 to 1894, and of 62 per cent from 1894 to 1900. This excellent showing was not entirely due to metering. The introduction of a business method of administration modeled after the English municipalities, and the completion of some new pumps, contributed to the result.

The head of the department, thanks to the hearty co-operation of Mayor Johnson, has been allowed to make all appointments and removals without interference from anyone, and in ignorance of the politics of all employees.

If the operating expenses and repairs had increased 61 per cent during the last six years, which was the average increase of the two previous periods, the total expense would have been $443,354.81 in 1906. The actual expenses were $135,725.87 less than this. The interest and depreciation on the meters was not half as great as it would have been on the additional machinery and mains that would have been necessary had the department not invested about $800.000 in ⅝-in. and ¾-in. meters during the last four years.

If the department had not spent $800,000 on these meters, it would have had to spend $1,600,000 for other extensions in addition to what actually was spent. Seven per cent on this extra $800,000 would be about $56,000. Those additional amounts of fixed charges, together with the $135,725 saving

in operating expenses, just mentioned, make a total saving through the meters and other improvements in 1906 of over $190,000. This has all gone to the people in reduced charges for water.

The city obtained its water from an old tunnel extending only one and a third miles from shore prior to 1904. The increasing discharge of sewage into the lake from the rapidly-growing city so contaminated the water supply that the tunnel now in use was undertaken. It should have been finished in 1902, but the contractors, who were losing money on the contract, had not extended the tunnel a single foot for eleven months when the water department took direct charge of the work at the close of 1901 and completed the job by direct labor by the beginning of 1904. Immediately the deaths from typhoid per 100,000 population declined so rapidly that in 1906 there were only fourteen cities with a lower death rate from this cause among the thirty-eight cities having over 100,000 population. The death rate from typhoid in 1906 was 20.2, or less than one-third that of Cincinnati, Pittsburg or Philadelphia.

The plant has a structural value, according to careful computation, of about $11,000,000, and a bonded indebtedness of $4,441,000. The rest of the plant has been paid for out of earnings. During 1906 the earnings of the department were over $200,000 in excess of interest on the bonded indebtedness and such allowance for depreciation, to wit: 2 per cent on the structural value, as the experience of the last fifty years has shown to be necessary.

A private company would have paid taxes of about $100,000, which the public plant did not pay. On the other hand, a private plant would have charged for water for fire purposes, street cleaning and sprinkling, public parks and playgrounds, schools, and other public buildings, fountains, etc., over twice this amount.

Of the 70,000 services in use, about 57,000 are now metered, and the department has just bought 10,000 more meters, which it will set during the ensuing twelve months.

Large extensions of street mains are also well under way.

Bacteriological analyses of the water are made daily, and every effort is being put forth to make the department a model for other municipal undertakings, such as electric light, garbage works, street railways, etc., as the city is now undertaking, or may undertake in the near future.

BUFFALO

By Prof. A. C. Richardson, Buffalo, N. Y.

The first company which undertook to supply the citizens of Buffalo with water was the Buffalo and Black Rock Jubilee Water Company, which was organized in 1826 and incorporated in 1827. Before 1832 it had laid sixteen miles of wooden pipes, which were simply logs bored through from end to end, with one end sharpened to fit into the next log. Some of them are still dug up occasionally. The source of supply was the Jubilee Springs, on Delaware Avenue, near Ferry Street, and as this was higher than any

part of the district then supplied, no pumps were necessary. The Jubilee Water Works continued in existence, with commissioners of its own, in addition to the system next to be described, down to about 1898, and the land containing the springs belonged to the city as late as 1902.

This system supplied but a small part of the city, and in 1849 the Buffalo City Water Works Company was incorporated with a capital of $200,000, which might be increased to $500,000. There was trouble at first about raising the capital. The common council voted to subscribe $100,000, but this action was reconsidered, and the subscription was refused. At last, however, two Philadelphia contractors subscribed for enough of the stock to ensure the construction of the works, with the tacit understanding that the contract for the construction should be given to them. The work was begun in 1850, and completed in 1851, and the works were formally opened January 2, 1852.

The water was taken from the margin of the Niagara River, the inlet being situated on Bird Island Pier; and a tunnel about four feet in diameter and 330 feet long, running under Black Rock Harbor and the Erie Canal, connected this inlet with the wells under the pumps. Of these latter, there was but one at first, built in 1851, with a capacity of 4,000,000 gallons in twenty-four hours. Another was added in 1866, having a capacity of 6,000,000 gallons. The water was pumped into a reservoir which would hold 11,000,000 gallons, built on the block bounded by Niagara, Connecticut, Vermont Streets and Prospect Avenue, and was then distributed to the city by 33.9 miles of pipe of various sizes. This plant was the nucleus of the present water works, which have been extended and improved until they are now among the largest in the country. The pumping station is the largest under one roof in the world.

The charter of the company gave the city the right to acquire the plant at any time within twenty years from the date of incorporation, and in 1868 it was deemed necessary to do so. Accordingly, on May 7th of that year the legislature of the state authorized the city to issue bonds to the amount of $705,000 for this purpose. The purchase was consummated and the city, by three commissioners, one of whom was the then mayor, Chandler J. Wells, took formal possession of the plant August 17, 1868.

The systems above described were supplemented by a large number of wells in various parts of the city, and an old-fashioned pump with a long iron handle was a not uncommon sight on the street corners when the writer came to live in the city in 1883. All these, however, have long since been abandoned and filled up.

By the time the city took over the works in had become necessary to take measures for obtaining a more ample and a purer supply of water. Accordingly, in 1870, plans were made for extending the tunnel, duplicating it, and erecting a new inlet pier further out in the river. This work was completed and the water let in December 27, 1875. The new pier was located at a point in the river where the water is about sixteen feet deep and the current flows at the rate of seven to fifteen miles an hour. The two tunnels connecting it with the shore wells are about 985 feet long, and

together have a capacity of 350,000,000 gallons a day. There are now in the pumping station nine steam pumps of various makes and one electric pump, which together have a capacity of 212,000,000 gallons per day. Another large electric pump, for which bids have been received, will probably be added soon.

A new reservoir, on the block bounded by Best, Jefferson, Dodge and Masten Streets, was begun in June, 1889, and completed in July, 1894. It has a capacity of over 116,000,000 gallons when filled to a depth of thirty feet, and the surface of the water is then 113 feet above the level of the water at the inlet pier and 685.23 feet above mean tide at New York. As soon as the new reservoir was in use the old one was abandoned and shortly afterward pulled down. Its site is now occupied by the armory of the Seventy-fourth Regiment, N. G. N. Y., one of the finest and most imposing buildings in the city.

According to the reports of the water department the average per capita consumption of water was 319 gallons a day in 1903-04, and 336 gallons a day in 1904-05. This is an enormous consumption—greater than in any other city in the world. The calculation of it is based upon the plunger displacement of the pumps, with an allowance of 10 per cent for slip, or imperfect working of the pumps. But a special commission on water supply, appointed by the mayor in 1905, expressed in its report the opinion that the pumpage thus calculated is largely in excess of the actual pumpage, basing this opinion on the results of meter measurements on one of the larger pumps. If, however, a deduction of 20 per cent is made from the gross measurements, the average daily consumption per capita in 1903-04 would be 280 gallons, and in 1904-05, 300 gallons; and this is enormously greater than that of the largest cities in this country. New York, for instance, pumps 113 gallons per capita daily, Chicago 161.5, Philadelphia 221.9. It is quite certain that a very large part of the water pumped is wasted without doing good to anybody. For instance, in the fiscal year 1904-05, 7,795 buildings were inspected, in which 7,312 leaky fixtures were found; and the repairing of these fixtures made an actual saving by meter measurement of over 4,000,000 gallons a day. Last year a similar inspection of 3,131 buildings disclosed 2,849 leaky fixtures, the repair of which caused a saving of over 2,000,000 gallons a day. It seems likely, therefore, that if all waste could be eliminated the present supply would be not far from sufficient for the city at the present time.

Where meters are not used, the charges vary according to the size and frontage, from $2.50 to $9.00 a year, besides a special charge for each bath tub, water closet, hose-sprinkler, etc. The meter rate is six cents a month per thousand gallons for the first 22,500 gallons, and for all over that amount two cents a month for each thousand gallons; but no meter will be furnished unless the annual amount per meter is at least $5 for a ⅝-in. meter, $10 for a ¾-in. meter, and so on in proportion for larger meters.

"The change in our meter ordinance," says Buffalo's official report for 1905-06, "making a lower rate for the smaller meters, has put us in position where the smaller meters could be installed, and we have therefore placed

more meters than in any year previously; but we have still been hampered for lack of funds, or we should have placed a great many more. We have installed during the year 315 new meters, and now have 2,001 meters actively in use.

"The experience of all water departments is that a liberal use of meters causes a reduction in water used and makes a more equitable distribution of the water rates. . . . It does not reduce the legitimate use, but does stop the unnecessary waste, and almost invariably reduces the amount paid for the use of water, and thus becomes a benefit to all concerned."

The special commission above mentioned also says in its report: "While we believe that by a thorough and efficient system of inspection much of the unnecessary waste of water can be prevented, we also feel that this can be but a partial remedy, and that the only perfect remedy is the installation of a meter on every service, not only to limit waste in house services, but to exact equitable rates for water consumed, and to aid in the detection of leaks from street mains and service pipes.

"Yet we recognize that there is a strong prejudice against meters in the minds of many people, and therefore believe it to be better, instead of installing meters on all services at once, to proceed gradually, confident that before long the good sense of the people of Buffalo will indicate clearly to them that it is the proper system to adopt for the distribution of water and collection of water rates, just as it is in the case of gas and other supplies."

To quote again from the report of the special commission above named: "We believe that under ordinary circumstances the water supplied to the city through the present intake and tunnels is wholesome and good, but the evidence is conclusive to our minds that there are times when it is polluted to a degree which imperils the health of the city, and that the causes which produce this pollution are increasing in effectiveness, so that in the not distant future the water from the present source will become much more dangerous. . . . . The present intake is sometimes very seriously interfered with by ice, which checks and has almost stopped the flow of water to the pumps, causing great inconvenience to many consumers and a dangerous condition as regards fire. The objections to the present source of supply, intake and tunnel are so great that a new source of supply should be determined upon, adopted and brought into use at the earliest date possible."

The intake and tunnels have been already described. As has been said, there are nine steam pumps and one electric, the last named having been added to the plant in 1905. Most of the others are old, have seen their best days, and are expensive to run. They are housed in a building 640 feet long and 102 feet wide, located at the foot of Massachusetts Avenue, with the Erie Canal on one side and the New York Central Railroad on the other. This entire building has just been rebuilt entirely fireproof. There is a high-pressure service and a low-pressure service, both of which are connected directly with the pumps, which maintain a pressure of about fifty pounds per square inch at the pumps for the low-pressure service and seventy-five pounds for the high-pressure service. Besides this, the large reser-

voir, above mentioned, is connected directly with the former and supplies the mains when the consumption causes a lowering of the pressure from the pumps.

Besides the objections to our present water supply system which have been named above, there is the very serious one that it is the only one we have, and that there is no reserve plant to use in case of accidents. And the possibility of accidents was brought home to us forcibly in 1905 by the fact that a large lumber barge broke away from its tow, floated down the river and was wrecked on the Inlet Pier. It took many weeks to get her off, and many more to repair the damage to the pier. "The damage was worse than we had anticipated," says the last official report of the water bureau, "and very few people realize how close a call they had to having their source of supply cut off completely, so that it would take months to resume its use."

The special commission before mentioned was appointed in 1905 to devise remedies for the defects of the existing system; and in accordance with their recommendations plans have been made and contracts let for the construction of a new pumping station at the foot of Porter Avenue, a new tunnel and inlet large enough to supply 400,000,000 gallons daily to the pumps (this with an eye to the future growth of the city), the inlet to be located in the Emerald Channel, where pollution has been shown by a long series of observations and experiments to be impossible, and a branch tunnel connecting the new station with the old so that the new inlet can supply both. Then, when the new plant is completed and in use, the old intake and tunnels are to be closed so that no water can reach the pumps from them, while the old plant is to be kept as an auxiliary and reserve. The new system, it is estimated, will cost $2,800,000, and its construction is already under way.

The charter requires the water department to be self-supporting. It must pay all running expenses, including extension of mains and principal and interest of bonds issued for its benefit, out of its own revenues. The extension of the pipes is somewhat hampered by this necessity, as there is always a lack of funds for this purpose. All other obligations must be met first. For instance, there are about eight miles of pipe to be laid, the money for which has not yet been earned. If any surplus were left after meeting these obligations it would be turned into the general fund. But this state of things, according to an official in the comptroller's office, has never occurred since the city has taken possession of the water works.

SAN FRANCISCO, CAL.

By MURRAY GROSS, University of Pennsylvania, Philadelphia.

The City of San Francisco does not own a municipal water plant but is being supplied by a private corporation, viz., The Spring Valley Water Company.

Up to the sixth decade of the past century, San Francisco received its domestic supply of water from watering carts, wells and springs. Supplies for the hand fire-engines were drawn either from the bay or from large

cisterns built at street crossings and kept filled for the use of the volunteer fire department. The serious fires which occurred during the fifties demonstrated the inefficiency of the fire protection, but as the credit of the city did not permit construction of municipal water works, a law was framed, known as the law of 1858, to encourage private enterprises to embark in the business of supplying cities and towns in California with water. For the purpose of regulating the price at which water ought be sold, the law provided that rates should be established by a commission.

Under the protection of the law of 1858 a company was organized with two million gallons daily, but the rapid growth of the city and the increasing demands for water led to the creation of a new company, under the name of the Spring Valley Water Works, by local citizens. This company secured considerable tracts of land and water rights in secluded mountain forests in San Mateo County. On the first of the year, 1865, both companies became one under the name of the Spring Valley Water Company.

Between 1865 and 1905, the population and consumption of water in San Francisco steadily grew. Water was required and demanded everywhere and at elevations varying from sea level up to five hundred feet above tide. With this growth, the reservoir, pumping and pipe system kept pace, so that by the end of 1905, the distributing system showed a net mileage of four hundred and forty-one.

The water sources of the Spring Valley Water Company, as at present developed, may be divided into three separate groups:

First, the Peninsular Reservoir supply, in San Mateo County, comprising three storage reservoirs, with capacities of about 950, 5,500 and 1,900 million gallons, respectively. The water product from these three reservoirs flows by gravity into the distributing system of San Francisco.

Second, the Alameda Creek system. No storage reservoir has as yet been constructed. The present supply drawn from this source is about 15 million gallons per day.

Third, Lake Merced, in San Francisco County, with an area of 400 acres. The average net yield of the lake is about 3 million gallons per day. During the period of four decades from 1865 to 1905 facilities have been developed necessary to bring the daily water supply up to 35 million gallons.

The following table shows the population of San Francisco in round figures for even years from 1870 to 1900, inclusive, and an estimate for 1910:

Year.	Population.	Daily Consumption of Water in Gallons.	Daily per capita Consumption
1870	150,000	6,040,000	40
1880	234,000	12,670,000	54
1890	300,000	20,430,000	68
1900	343,000	25,470,000	72
1910 (estimated).	455,000	34,900,000	80

In 1877 the board of water commissioners entered into negotiations with the Spring Valley Water Company for the purchase of its plant, offering the sum of $11,000,000, but the company declined this offer as not being

within several million dollars of the true value of the works. In Article XII of the new state constitution, adopted January 1, 1880, it became the duty of the board of supervisors of San Francisco to fix the compensation to be collected by any person, company or corporation engaged in the business of supplying water for the use of city, county or the inhabitants.

Section 19 of Article XI of the constitution, as amended in 1885, granted the right to persons and corporations to use the public streets for supplying water to the inhabitants on condition that the legislature shall have the right to regulate the charges.

The legislature of the state at its session in 1881 passed an act providing for the carrying out of the objects of Article XIV by imposing upon the board of supervisors the duty of requiring all persons or corporations engaged in supplying water to file statements each year, showing the names, residence and the amount paid by each rate-payer during the preceding year; the revenue derived from all sources and an itemized statement of the expenditures made for supplying water during the same time. The same act further provided that false statements or refusal by water companies to make statement should be held a misdemeanor; that water rates were to be equal and uniform; and that excess in charging rates should forfeit franchise.

In the year 1900, the new charter of San Francisco went into effect, a very prominent feature of which was a clause providing for the acquisition of a municipal water works system and another empowering the board of supervisors to fix and determine by ordinance the rate of compensation to be collected by any person, company or corporation for the use of water, heat, light, or power, and to prescribe the quality of the service.

As preliminary to fixing and establishing water rates under the provisions of the new charter, the city has had annual estimates made by its engineer as to the value of the properties and works of the Spring Valley Water Company. According to the statements of the company, its properties and works, at the beginning of the year 1901, when the first appraisement was made by the city authorities, should have had a minimum value of $26,932,485.

In the following table for five years ending 1906 is shown the valuation of the properties of the company by its own officials and by the public officials together with the taxes paid by the company:

Year.	A. Beginning year, 1901.	B. Expended by Company for Betterments.	C. Sum of A + B. Beginning of year.	Valuation by City Engineers. Beginning of year.	Valuation by Supervisors at beginning of year.	Taxes paid by Company during year.
1901*	$26,930,000	.....	.....	$24,667,800	$22,939,722	$203,257
1902†	.....	$974,732	$27,904,732	24,468,210	23,914,454	236,828
1903‡	.....	735,594	28,640,326	28,024,389	24,124,389	321,537
1904§	.....	718,939	29,359,266	24,673,212	23,121,502	348,222
1905	.....	462,438	29,821,704	25,001,441	.....	.....
1906	.....	510,751	30,332,455	25,450,327	.....	.....

* Municipal Report, 1901–2, p. 787. † Municipal Report, 1902–3, p. 942.
‡ Municipal Report, 1903–4, p. 509. § Municipal Report' 1904–5, p. 499.

It will be noted that the company expended for betterments during the five years from 1901-05 $3,402,455, but on the other hand that the valuation by the city engineer increased during this period only $782,527, or less than one-fourth of the sum expended. It may also be seen that while the valuation by the city engineer increased only $3^1/_{10}$ per cent, the taxes paid by the company during 1905 show an increase over taxes paid during 1901 of $82^1/_{10}$ per cent.

The water rates established by the board of supervisors upon the basis of its valuations have been constantly opposed by the company as being below its needs for operating expenses, taxes, interest and essential improvements, and on several occasions their application has been prevented by injunction.

CINCINNATI

By MAX B. MAY, ESQ., Cincinnati, Ohio.

Since June 25, 1839, the City of Cincinnati has owned and operated its own water works. Prior to that time water was supplied by private enterprises. The first settlers in 1799 were supplied by Griffin Yeatman from a common well in his garden at twenty-five cents for each family, payable every Monday morning.

In 1802 there was a rival private water works, which consisted of a large cask hauled on a sled. In 1805 water was supplied from a large hogshead on wheels. The first water works were operated in 1820 and consisted of a small wooden reservoir about six feet above the street, which was supplied by a chain pump operated by horse power, and the water was distributed from the tank to casks which were hauled away by consumers.

In 1821 the owner of the water works, which in the meantime had been improved by the laying of wooden mains, offered to sell them to the city for $30,000, but this was rejected by the popular vote of 294 to 25, and in 1835 a proposition to buy the water works, which in the meantime had been much improved, for $275,000, was defeated by a vote of 1,274 to 956. Finally in 1838 the city voted to buy the water works for $300,000 by a vote of 1,573 to 321.

In 1842 Nicholas Longworth urged council to provide a site for a higher reservoir, and offered his Eden Park property at $500 an acre. Council refused this, but later bought the property for $30,000 an acre.

Prior to 1896 an agitation was started for a new water works which should be built, and in that year the legislature authorized a commission of five to construct a new water works and to expend $6,500,000. The commission, consisting of August Herrmann, Maurice J. Freiberg, C. M. Holloway, Leopold Markbreit and W. B. Mellish, secured the opinion of experts, whose report provided for the location of the new water works plant at the village of California, on the Ohio River, about twelve miles from the center of the city. The main plans of the new water works are as follows: A low-service pumping station and intake situated immediately below the village of Cali-

fornia, with an intake tower on the Kentucky side of the Ohio River connecting the same with the pumping station by a tunnel to be driven under the river bed. The water from this station is delivered through two 60-inch diameter force mains to two large subsiding reservoirs, located on high grounds back of the village of California. These subsiding reservoirs have a total capacity of 300,000,000 gallons of water. Adjacent to these reservoirs are coagulating basins. Thence the water by slow gravity enters sand filters, from which the water enters a clear well water reservoir, and thence through another tunnel, through which it is delivered to the high-service pumping station, which is located about four and one-half miles west of the intake. From this station it is pumped into the present Eden Park reservoir and distributed throughout the city. It is expected that filtered water will be furnished by January 1, 1908, latest.

It was soon found that the original cost of $6,500,000 would not be sufficient, and additional legislation was secured authorizing a further expenditure of $3,500,000. It now appears that it will require about an additional million dollars to complete the work, and a committee of citizens has recently reported in favor of legislation providing this additional amount.

The supply at present is, of course, adequate, and will be for very many years to come. It is difficult to estimate the charges to consumers, inasmuch as various businesses gave different rates. The average dwelling house consists of from nine to twelve rooms, and costs about $6.50 a year. Of course factories, bakeries, laundries, etc., have special rates which it is impossible in this brief report to state. Meters are furnished and consumers are charged 7½ cents per 100 cubic feet, irrespective of the quantity consumed, with a minimum rate of 2 cents per day.

The average daily per capita consumed under the old water works was 140 gallons. This was due to the condition of the old pumps. Under the new water works the average daily per capita consumed is about 125 gallons. The experience with water meters has not been satisfactory. This is due to the fact of the charge of the minimum 2-cent rate per day. The average consumer using the meter finding that he has to pay this minimum charge, wastes as much water as he did without the meters.

Prior to January of this year water was furnished from the old pumping station on East Front Street, the water there being much contaminated by sewage which enters the river many miles above. This naturally caused much typhoid fever throughout the city. Since the water has been pumped by the new works at California, the intake of which is above the city, the number of cases of typhoid has greatly decreased, and it is expected by the health authorities that when filtered water is furnished there will be an additional decrease of this dread disease. Of course the present condition of the works, which have just been completed, is excellent and will undoubtedly remain so for many years.

The water works pays its own expenses, and also provides a sinking fund for the redemption of the $10,000,000 water works bonds now outstanding. The estimated receipts for the water works department for the year 1908 from all sources will aggregate close to $1,100,000. Out of this sum

there is used $354,955 as interest on $10,000,000 of bonds, $21,295.75 old charges. One hundred and forty thousand dollars are put aside annually for sinking fund purposes. The approximate cost of operating and maintaining the new plant, including the filter, will be $275,000, and the costs of the controller, assessor and collection division, repair and extension department about $220,000. Within forty years therefore at the present rate the entire water works should be paid for.

NEW ORLEANS

By JAMES J. MCLOUGHLIN, ESQ., New Orleans, La.

The water supply system of New Orleans is at present in a state of transition, and it is somewhat difficult to present a satisfactory summary of the situation.

The present system was constructed by a private corporation which had been granted a fifty-year monopoly that would expire in 1927. But some seven or eight years ago, the company's extortions, unfairness and general inefficiency were so unbearable, that a suit was brought which resulted in the forfeiture of the company's charter, and the abolition of its monopoly. The company is now in the hands of a receiver, and its property will soon be sold at public auction to effect a final liquidation. When that is done, the present water supply system will cease to exist. As a matter of public order and necessity, the receiver is operating the system by sufferance of the municipal authorities, as all realize that it would be a public calamity to shut off the city's water supply.

The city is at present busily engaged in constructing a water system, under a special tax levied to pay for the same. This system will be owned and operated by the city, and will be in operation by the end of 1908. Until then, the present inadequate pipes of the receiver will have to be utilized. When our water system was first devised, some seventy-five years ago, it was established as a private monopoly; operating as such for some thirty years, it was then bought out by the city, and for about ten years the city ran it. The disastrous results of the Civil War, and the ten-fold more disastrous afflictions of the reconstruction period, so exhausted the city's ability to make needed repairs and improvements to its municipal utilities, that in order to have the system kept going, in 1877 the water system was transferred to a private corporation with a fifty-year monopoly right. The corporation took charge of a system of some sixty miles of pipes, and from the very start adopted a system of "get-all-you-can" out of its franchise, instead of a wise extension of facilities. When its charter was forfeited, after thirty years of profitable operation, its pipe mileage had increased only seventy miles, and it was still supplying the raw muddy water of the Mississippi River, without filtration or even settling. The supply was totally inadequate to the needs of the population. The charges to the consumers were grossly extortionate, and discriminative, some consumers paying one-half what others, less favored, had

to pay for similar service. Water meters were not allowed unless to large consumers, and then the meter had to be installed at the consumer's cost; but the meter measurement was a farce, because, as was shown on the trial for the forfeiture of the company's charter, the meter registered in cubic feet, and to one consumer, the company would bill the supply at eight gallons per cubic foot, to another at ten gallons, and to some unfortunates twelve gallons per foot. The city had no control whatever over the charges, or the accounts, of the company. True, a minority of the board of directors was composed of city officials, but in practice these city members were ignored, or else neglected their duties. In fact, the water supply for this great city, on the banks of a great river, with an inexhaustible supply of good water, was grossly inadequate. Therefore, simultaneously with the enactment of the legislation which resulted in the forfeiture of the company's charter, the people of New Orleans, by proper taxation, issued sewerage and water bonds to the extent of twenty-four millions of dollars, which fund is being spent in sewering and draining the city, and in erecting a modern water system. Work was begun some five years ago, and is now well on toward completion.

This paper is not concerned with the sewerage and drainage improvements, which are now in partial operation, to the great satisfaction of the people, and I will not devote any space thereto, beyond saying that they form parts of one comprehensive whole, whose completion will make of New Orleans one of the most desirable cities in America for the health and comfort of those who dwell therein.

New Orleans is situated on both sides of the Mississippi River, and draws its public water supply from that river. Under the plans now being carried out, there will be a system of 453 miles of pipe, that will supply pure, filtered water throughout the city. The capacity of the works will be sufficient to provide for a per capita consumption of 100 gallons of filtered water. Water meters will be supplied to consumers who desire them. The rates for water must be fixed at such a price as will furnish the water at cost, as no profit is to be made by the city from the sale of water. Water for the sewerage system will be supplied the householder free.

The cost of this system is fixed at $6,718,945.20. Of the 453 miles of pipes 145 miles have been completed, or are now nearly completed, and contracts for 308 miles will be let this year. The machinery for the main distribution and filtration station has been bought, and that station is in course of erection. With the completion of this comprehensive set of plans, New Orleans will have one of the best water systems in the country. The water of the Mississippi River is well known for its freedom from impurities—the sand, or silt, which forms so great a part of its volume not being rated an impurity,—and after it is filtered to remove the mud, or sand, it becomes pure and limpid. The volume of water is so great, that we will never fear diminution of supply. And we need no extensive watershed to collect into our reservoirs the water required. With so favorable a situation, the people of New Orleans congratulate themselves that they have solved to their complete satisfaction that greatest problem of modern cities—a pure and adequate water supply.

DETROIT

By DELOS F. WILCOX, Ph.D., Secretary Municipal League, Detroit, Mich.

The public water supply of Detroit has been under the management and control of the city from the beginning. A board of trustees was first appointed by the common council on February 24, 1852. In the following year a special act approved by the common council was passed by the legislature establishing the "Board of Water Commissioners of the City of Detroit." This board was to consist of five members appointed by the common council, the first commissioners to serve for three, four, five, six and seven years respectively, their successors to be appointed for terms of five years. According to this arrangement one new commissioner would be appointed every year. This plan has been followed up to the present time, except that the appointment of the commissioners was some years ago transferred from the council to the mayor, but subject to confirmation or rejection by the council.

During the fifty-four years since the board of water commissioners was established forty-two different individuals have served as commissioners. During the last twenty years comparatively few have been reappointed at the expiration of their terms, but in the earlier days the continuity maintained in the personnel of the board was remarkable. During the first year of the board's operations, 1853, Mr. Edmund A. Brush was chosen president. He was re-elected every year until 1868, when Alexander D. Fraser, who had served on the board continuously from 1855, was elected president. Mr. Fraser served for three years. In 1871, Mr. Jacob S. Farrand, who had been a member of the board since 1865, was elected president, and served for one year. He remained on the board, however, and was chosen president again in 1880, and served continuously in that capacity until July 9, 1890. From 1872 till his death, in 1885, Chauncey Hurlbut served as president of the board. He had been a member of the board for four years prior to his election to the presidency. Since 1890 the board has had fourteen different presidents.

Under the act providing for the board of water commissioners this department of the city government is rendered almost altogether independent of the common council and the mayor. While it is true that the common council has authority to remove any water commissioner by a two-thirds vote upon charges and after a hearing, the water commissioners are not required to submit their estimates to the common council or board of estimates, nor to report their financial transactions to the city controller. The debt of the water board is independent of the general city debt, and is not included in the statutory debt limit. The city pays to the water board a lump sum of $75,000 every year for interest and sinking fund and in return receives without charge water needed for public purposes. Out of this fund and the receipts from water rents the department itself takes care of the water debt, both principal and interest, and pays the current expenditures of the department.

The water supply is taken from the Detroit River, and is unlimited in quantity. All the conditions are favorable for low rates, as the site of the city is almost level and only a few feet above the level of the river. The following are the rates charged to consumers:

For Metered Water.

Minimum rate $1.75 per quarter, $7.00 per year. For first 30,000 gallons used, per quarter, the minimum rate. All in excess of 30,000 gallons, per quarter, 2¼ cents per thousand gallons.

Assessment Rates per Annum.

For each family for general household purposes, $2.60; for one bath-tub, $1.00; for each additional bath-tub, 60 cents; for automatic water closet, $1.60; for each additional closet, 60 cents; for each hand wash basin, 48 cents; for hose bib or connection, premises 30-feet front or less, 60 cents; for hose bib connection, premises 30-feet to 60-feet front, 80 cents; for hose bib connection, premises 60 feet to 100 feet, $1.60; for livery and private stables, for each horse, $1.20; for dray and team horses, each, 60 cents; for cows, each, 60 cents; for stores and offices, $1.00 to $12.00; for bakeries, average daily use for each barrel of flour, $2.00; for grocery and provision stores, from $3.00 to $50.00; for saloons, $6.00 to $50.00; for bar with faucet, from $8.00 to $50.00; for fish houses, from $6.00 to $50.00; for beer pumps, $2.00; for barber shops, for each chair, $2.00; for hotels and taverns, in addition to family rate, for each room, 60 cents; for boarding schools, $4.00 to $50.00; for butcher stalls, each, not less than $3.00; for workshops, for ten persons or under, $3.00; for workshops, for each additional ten persons, $1.00; for boarding houses in addition to family rate for each roomer or boarder, 40 cents; for building purposes, for each one hundred yards plastering, 5 cents; for each perch stone, 1 cent.

Special rates are given for green-houses, slaughter-houses, printing-offices and lawns of more than 100 feet frontage. Street sprinklers have to pay $50.00 each wagon. Fountains pay from $5.00 to $20.00. Where more than one family live in the same house and are supplied through the same faucet, the second and each additional family has to pay $1.40 a year for water for general household purposes.

The average number of gallons pumped per day during the fiscal year ending June 30, 1906, was 61,357,019, of which 18,239,174 was metered and the balance unmetered. The estimated number of persons supplied was 383,697, making a total per capita consumption of 159.9 gallons per day. This includes all of the water pumped, whether used for public purposes, for manufacturing, for hotels, for ordinary family use, or for any other purpose. The board supplies several outlying villages with metered water. The board lays the mains, but the expense is paid by the village authorities. The village authorities also pay for the water, and collect from individual consumers as they see fit. The average amount of water supplied in this way to outside villages was 500,657 gallons per day. The average daily pumpage has increased from 1,030,866 gallons in 1853 to 61,357,019 gallons in 1906, while the population of the city has increased from 20,000 in 1850 to approximately 263,000 in 1906, which shows that the pumpage of water has increased more than three times as rapidly as population. The average amount pumped for each family supplied in the year 1853 was 70,868 gallons. This average increased to 271,607

gallons in 1906. The pumpage per family reached its highest point in 1888, when 390,098 gallons were furnished on the average.

The total number of families supplied in 1906 was 80,848. The total number of meters in use was 6,346. As a general rule all business places are supplied with meters, and meters are installed in private residences wherever there is evidence of great waste. Of the total pumpage approximately two-sevenths passed through the meters. The revenue from metered water amounted to $0.0285 per thousand gallons while the balance of the revenue gave only $0.019 per thousand gallons of unmetered water.

The water supply of Detroit is exceptionally pure and wholesome. Taken from a deep, broad river only a short distance below Lake St. Clair, which is supplied from the Great Lakes Huron, Michigan and Superior, Detroit's water supply would be among the best in the world, if it were absolutely protected from pollution by the cities, villages and summer resorts along the Detroit River and Lake St. Clair. The city has recently annexed a suburb to the east mainly for the purpose of controlling its sewage. The board of health feared that even the slight amount of sewage drained into the river from this village might possibly contaminate the city's water supply. The total death rate per thousand estimated population during the year 1906 was eighteen. The average typhoid fever death rate during the past five years has been twenty per one hundred thousand population.

The present condition of the Detroit water works is, generally speaking, excellent. The total receipts, exclusive of loans, during the last fiscal year amounted to $676,604.80, of which $501,351.44 was from water rates and $75,000 from the general tax levy already mentioned. About $55,000 was received from outlying villages for laying water pipes. The total expenses for the year as reported by the secretary were distributed as follows:

Operation and maintenance	$156,195.36
Interest on debt	46,278.00
Purchase of real estate	21,156.85
Bonds paid off	189,000.00
For construction	370,937.68

The total amount of water bonds outstanding July 1, 1906, was $966,000. In addition to this, $1,834,000 had been redeemed or refunded since the establishment of the system. The estimated valuation of the property of the water works is as follows:

Real estate	$ 462,828.60
Pumping station, including buildings, tunnel, intake, machinery, etc.	2,633,815.95
Water pipe in use	4,836,451.79
Meters in use	110,966.48
Furniture and fixtures in offices	9,466.01
Tools and materials	119,319.66
Total	$8,172,848.49

There are now 683 miles of water mains in use; 8,014 gates; 4,355 fire hydrants; 558 fire cisterns and 73,699 service taps. The average head against the pumps is 120 feet. The average pressure is 52 pounds on the low service and 62 on the high service. About nine-elevenths of the water is supplied through the low pressure system.

There are at present no large plans for improvement on foot so far as water works construction is concerned. The city proposes, however, to build an intersecting sewer to take care of the sewage of the village of Fairview, recently annexed, so as to avoid any possible danger of contaminating the city's water supply.

On the side of the management and supervision there is a movement on foot to require the water board to submit its estimates and to report its financial transactions to the city authorities just as all other departments do. For some reason the board of water commissioners is very jealous of its financial independence and thus far has successfully resisted the attempt to reduce this department to the same organic relations with the city sustained by the public lighting commission, the board of health the board of education and other departments of municipal work.

WASHINGTON, D. C.

By DANIEL E. GARGES, Secretary to the Engineer Commissioner of the District of Columbia.

The water supply of the City of Washington is brought from the Great Falls of the Potomac River, in the State of Maryland, about twelve miles from the City of Washington. The first steps towards furnishing the city with water were taken about the year 1852, when an appropriation was made by Congress for the necessary surveys. The first appropriation was made towards the work in 1855, and was for the construction of the necessary conduits and reservoirs. The work was completed about 1858. It was originally contemplated only to supply buildings of the United States Government located in the City of Washington, which, until that time, had been supplied with water from wells. By an act of Congress, approved March 3, 1859, however, Congress provided that the inhabitants of the corporations of Washington and Georgetown should be allowed to lay the necessary mains in the streets of the two cities and levy a water tax therefor, and to connect these mains with the mains belonging to the United States. Authority was also given the corporations to make regulations regarding the distribution of the water and to establish a scale of annual rates for the supply and use of same, provided no expense devolved upon the United States, and it was further provided that when the supply of water was found to be no more than adequate to meet the wants of the United States Government, the supply to the citizens should be cut off.

This is the arrangement under which water is at this day supplied to the City of Washington. The control of the source of supply and the conduits,

reservoirs, and appurtenaces, is under the chief of engineers of the United States army, acting for the United States Government, and the distribution of the water to the citizens of the City of Washington and District of Columbia is under the control of the commissioners of the District of Columbia. There has recently been constructed a filtration plant, through which all of the water supplied passes before it is delivered to the authorities of the District of Columbia for distribution, and this plant is under the jurisdiction of the chief of engineers. The pumping station of the District is located adjacent to the filtration plant, and the water is delivered to this pumping station and distributed from it to all points in the city and District. This station is controlled by the district commissioners.

The cost of bringing the water from Great Falls to the city was $12,000,000, and the expense was borne by the United States. The cost of the distribution system was about $8,000,000, and was paid for entirely from the water taxes and water rents levied upon the citizens of Washington. The cost of the filtration plant was about $3,000,000, and it was paid for one-half by the United States and the other half from revenues of the District of Columbia. The capacity of the filtration plant is 75,000,000 gallons daily, and the average consumption is 68,000,000 gallons daily. While the supply is adequate at the present time, it is dependent upon one conduit, which brings the water from Great Falls, and in case of anything happening to this conduit, which was built about half a century ago, the water supply would be cut off. Both the chief of engineers and the commissioners have urged upon Congress the necessity for the construction of an additional conduit, but no appropriation has yet been made for the purpose.

The average daily per capita consumption is 200 gallons. This is palpably excessive, and is due in part to leaks and wastage. In order to prevent such wastage and also to establish a more uniform system of water rates, the commissioners are installing water meters. About 4,000 of such meters have been installed in private residences, and they have been required for a long period in business and manufacturing establishments and other establishments using large quantities of water. At present, however, and until the installation of water meters in private residences is completed, the charges to the consumers are based on the number of stories and frontages of the houses.

On all premises two stories high, with a front width of 16 feet or less, the charge is $4.50 per annum, and for each additional front foot, or fraction thereof, there is an additional charge of thirty cents per annum. For each additional story, or part thereof, the above rates are increased by one-third. This system of charging for water has never been satisfactory, however, and is abandoned as meters are installed. The rate for water supplied through meters is three cents per hundred cubic feet.

The experience of the city with water meters in business and manufacturing establishments and in private residences as far as they have been installed, has been very satisfactory, both as to preventing unusual consumption and as forming a better basis upon which to make charges to consumers. The regulations as to the installation and use of water meters are

given below.[2] In this connection it should be stated that the meters in business establishments are installed and paid for by the owners of the property, while those in private residences are paid for out of the water revenues. These revenues are made up from rentals received for the use of water and assessments levied for the laying of mains. The rate of assessment is $1.25 per front foot of property abutting on the main, and this frontage is considered as serving the lot to a depth of 100 feet. All frontage of corner lots over this amount is assessed as additional frontage.

The distribution system is supported entirely from the water revenues and by provision of law the revenues shall not exceed the cost of furnishing water, so that there are no profits on the system. The rates to consumers are adjusted, however, from time to time, and recently were increased 25 per cent in order to pay for necessary extensions of the water system to the outlying sections of the District. With this increase, however, the rates are lower than in other cities with a population equaling that of Washington.

As before stated, the conduit bringing the water to the City of Washington is old, and a new conduit is very badly needed. The balance of the system, however, both of supply and distribution, is in excellent condition, and the only improvements contemplated are the extension of the supply to places, where water is not at present furnished.

[2]RULES AND REGULATIONS OF THE DISTRICT OF COLUMBIA CONCERNING WATER METERS.

Authority is vested in the Commissioners of the District of Columbia by acts of Congress.

I. The supply of water shall be determined by meter to all manufacturing establishments, hotels, swimming baths, and all premises for business purposes on which the water rent, according to the schedule of rates, is twenty-five dollars or more per annum.

II. Every water meter before being placed shall be sent, with a memorandum of the owner's name and the location of the premises where the meter is to be used, to the water department, for testing.

III. Consumers are required to keep their meters and appurtenances in repair at their own expense.

IV. All meters and appurtenances shall be placed at the consumer's expense.

XI. No water from the mains shall be introduced or used on premises supplied through water meters excepting that which passes through the meter.

XIX. The rate to be charged for water supplied through meters shall be three cents a hundred cubic feet.

XX. A minimum rate of four dollars and fifty cents ($4.50) per annum, to be charged quarterly, will be made against all premises supplied with water by meters.

Attention is invited to the following act of Congress:

"That any person who, with intent to injure or defraud the District of Columbia, shall make or cause to be made, any pipe, tube, or other instrument or contrivance or connect the same or cause it to be connected with any water main or service pipe for conducting or supplying Potomac water in such manner as to pass or carry the water, or any portion thereof, around or without passing through the meter provided for the measuring and registering the Potomac water supplied to any premises, or shall without permission from the Commissioners of the District of Columbia, tamper with or break any water meter or break the seal thereof, or in any manner change the reading of the dial thereof, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by imprisonment not exceeding six months or by a fine not exceeding two hundred and fifty dollars."

The above rules went into effect August 17, 1906.

Prior to the installation of the filtration plant it had been claimed that the Potomac water was the cause of the greater proportion of the cases of typhoid. After the plant was installed and put in operation there was not a very perceptible decrease in the number of cases, and the medical authorities looked around for other causes. An investigation by the United States Marine Hospital service showed that the fifty shallow wells which were located in various parts of the city and suburbs were polluted, presumably from sewage contamination, and all these wells have been recently closed. Another cause was claimed to be the milk supply, and steps have been taken to regulate the cleansing of cans, utensils, etc., at the dairy farms and to prevent the use of water from polluted wells for this purpose.

PROVIDENCE

By FRANK E. LAKEY, Boston, Mass.

The water supply of Providence has never been furnished by private enterprise. Prior to the installation of the present system of public water works, several firms and families combined to obtain a water supply, but no agreement to supply the whole city from private sources has ever been attempted.

The history of the establishment of municipal water works is a brief one. During the sixties (1869) the Pawtuxet River was tapped, and, notwithstanding the growth of the city, still furnishes an abundance of really good water. The establishment of Hope, Fruit Hill and Sockanosset reservoirs gives sufficient head, while the installation of high-pressure services (composed of ninety-two flush hydrants), protects the numerous manufacturing plants against fire.

The water is pumped from the Pawtuxet River on to slow sand filters, situated on the opposite side of the river from the regular pumping station. It is carried under the river to the pumping station by gravity. It is pumped into a storage reservoir located upon a hill about one mile distant and 181.75 feet above the river. From this reservoir it flows into the city by gravitation, directly supplying a second storage reservoir within the city limits, and also that portion of the city which is of sufficiently low elevation to be served by gravitation. To supply that part of the city of too high an elevation to be served by these reservoirs, a third reservoir is located in the town of North Providence. The water is pumped by supplementary pumping machinery from the second reservoir above mentioned, or from the mains, into the high-service reservoir. This supplementary pumping machinery can also supply the high-service district, if the reservoir should be out of service, by pumping directly into the mains. In addition to the regular distribution pipes there is an independent high pressure fire system (deriving its supply from the high service) for protecting an area of about one-half of one square mile in the center of the business portion of the city.

The supply seems to be adequate for all demands for many years.

Other streams within twenty miles can be drawn on later if necessary, and use could be made of the salt water of the bay for fire purposes if urgently needed. The present filthy condition of the water in the upper bay, known officially as the Providence River, makes this last use one to be employed only in the last extremity.

The receipts for water rents for 1906 were $708,747.93, an increase over the previous year of $20,875.22. The net cost of the water works for construction from November 8, 1869, to January 1, 1907, is $7,228,867.84, upon which there has been a revenue for water sold of $13,273,770.12. The net debt September 30, 1906, was $4,072,915.52. The excess of receipts over management and interest in 1906 was $22,867.13.

The charges to consumers for all water consumed through a single tap up to $600 in value is two cents per 100 gallons. If in excess of $600, one and one-half cents per 100 gallons, provided that in no case where a meter is used the annual charge shall be less than $10.

The use of meters has reduced the waste 85 per cent. The average daily consumption is sixty-eight gallons per capita. The average daily use per service pipe, of which there are 25,094 in use, has been 600 gallons in 1906, or 15,005,600 gallons. Twenty-one thousand eight hundred and fifty-two meters are used by a population of 219,800, of which the estimate for the city is 203,000, and for the suburbs, 19,800.

The public health of Providence has been excellent for years. Since 1884 the superintendent of health has kept very full and accurate statistics of the cases of typhoid fever. In the twenty-three years last past, one outbreak has been traced to polluted city water. This occurred in 1888. In November, 1891, an outbreak was suspected to be due to the infection of the city water supply, but this was not proven. The supply is taken below a number of manufacturing villages, containing many foreigners, whose habits are sometimes open for criticism. Since 1855 the highest ratio (149 in 100,000) was in the year 1865, at the close of the Civil War. The next highest was in 1882 and 1883 (122 and 109), and the third in 1888 (83). Since that date the ratio has steadily fallen. Hence the superintendent, in his report for 1903, says: "It is improbable that the source of the water supply has been specifically contaminated except on three or four occasions, and that on the whole it has furnished an excellent supply. The fall in the death rate from typhoid fever may be fairly attributed to the introduction of city water." During 1906 the city water has been filtered. The beds are now being covered by wooden frames for the good of the service.

The following table shows the removal during the year of 97.3 per cent of the bacteria of the river water forming the water supply:

MONTHLY AVERAGE OF BACTERIA PER CUBIC CENTIMETER.
(48-hour counts on 10 per cent gelatine media.)

MONTH.	RIVER WATER.			FILTERED WATER.			Percentage Removed.
	Max.	Min.	Ave.	Max.	Min.	Ave.	
January	3,250	400	1,068	264	6	38	95.4
February	5,200	400	1,572	180	8	52	96.
March	3,500	250	723	215	7	54	92.5
April	2,800	400	1,019	164	5	31	95.5
May	4,000	400	1,915	119	3	12	99.2
June	3,100	200	1,633	91	3	16	98.3
July	1,500	500	1,047	31	2	7	99.2
August	7,500	400	1,450	129	2	10	98.7
September	5,000	250	1,302	190	2	12	98.8
October	5,000	600	1,636	181	2	18	98.5
November	4,800	600	1,776	135	5	25	98.5
December	2,000	300	1,016	99	6	24	97.2
Averages	.....	.....	1,346	.....	.....	25	97.3

The present condition of the works is satisfactory. Electrolysis is causing damage in certain localities. In some cases meters have been destroyed and service pipes damaged through this evil.

The profits are paid into the sinking fund. This fund, on September 30, 1906, amounted to $360,084.44. The profits since the installation of the service have been $1,887,563.14. For the past ten years the profits have been:

1897	$87,074.95	1902	250,582.95
1898	88,638.42	1903	260,507.58
1899	100,959.64	1904	275,961.55
1900	127,357.47	1905	125,900.73
1901	252,761.38	1906	22,867.13

The great shrinkage in the past year has been due to the very costly improvements made.

DULUTH

By W. G. JOERNS, Duluth, Minn.

The ANNALS of January, 1906, contained an article by the present writer on the gas service of Duluth under municipal management. As the gas service of Duluth is operated by the municipality in connection with its water service and was acquired by purchase from the private interest in connection with the water service, as one transaction, a description of one necessarily contained much that pertains to both. Reference is therefore made to the article in the January ANNALS aforesaid for a general history of the establish-

ment of the water supply of Duluth as well as to details of management, and here again attention is called to this plan of management, unique in many of its features, as a valuable source of suggestion to any municipality contemplating the municipalization of any public utility. Suffice it to say here, that the record of the private company was one of poor service, extortionate and discriminating charges, an impure water supply which became a serious burden on the health of the community, and a most corrupting influence in the political life of the community. The fight against the unsatisfactory and predatory private interest by the patriotic and more enlightened part of the community was a long and bitter one. The plant was finally municipalized in 1898; and the record since then, under municipal management, has been an unbroken line of successes. The source of supply was immediately changed and the people of Duluth have, under municipal management, been furnished water that in its excellence and purity challenges all comparison. Vast extensions of the system have been developed. The pipe lines have been more than doubled, the reservoir capacity increased sixfold since the city took charge of the plant, and the rates have been reduced to practically one-half the rates that were charged under the private management. The cost of service extensions and other incidental charges have likewise been reduced in proportion. The gas and water plant combined was originally purchased by the city for $1,250,000. The present bonded indebtedness of the city on account thereof, as shown by the last annual report, is $2,866,000. Both gas and water plants have at all times been maintained in a high state of efficiency and repair. Old pipe and machinery have been replaced by new, and the plant entire is to-day in the highest possible state of preservation. Attention is also called to the further important fact that, notwithstanding the reduction in rates and other savings to the consumer, there has been accumulated a surplus of approximately $140,000; and this surplus, instead of being allowed to lie idly in a sinking fund, has been expended upon the extensions of the plant. The combined water and gas plant was, in the last annual statement, inventoried at $2,955,000.

The present reservoir capacity of the plant is approximately 30,000,000 gallons. The average daily consumption is about 5,500,000 gallons, supplying approximately 50,000 consumers. The pumping capacity is four times the present rate of consumption, one-half thereof being in the shape of a steam, the other in the nature of a newly installed electric pumping plant.

The experience of the department with water meters has been very satisfactory, and it is seeking to extend the use thereof as much as possible. In fact two-thirds of all newer extensions are metered, and as fast as opportunity offers the older consumers are placed on the meter basis. It is the rule of the department that, once so placed, they are not permitted to return to a flat rate basis; and this rule has been upheld in the courts.

Under the careless and insolent management of the private company, the water supply became contaminated and a deadly menace to the public health. Epidemics of disease were directly traced to the contaminated water supply, and this fact had much to do with the creation of the public sentiment which finally resulted in a purchase of the plant by the municipality.

One of the first steps, under the municipal control, was to provide a pure water supply by the building of an extensive supplementary system. The water furnished the consumers since that time has been absolutely wholesome.

As before stated, the present condition of the works is first class. When first the plant was acquired from the private company it was in a run-down condition; but old and defective pipe and machinery has been replaced by new and modern material, and that part of the plant is to-day in a condition immeasurably superior to that in which the city found it when first acquired. Indeed it is the aim, as it has been the custom, of the department to maintain the entire works in the highest possible state of present efficiency and to make all renewals, repairs and substitutions with this aim constantly in view. It might be well to suggest at this point that about seven miles of force main, from the present pumping station to the main reservoir, is of 42-inch steel pipe construction. Serious question has, in doleful voice, been raised from time to time as to the probable life of this steel pipe, and the prophecy, in this regard, of the divergent special interest and of those financially and constitutionally opposed to municipal ownership, has been particularly dire. Recent investigation has, however, disclosed that this pipe, though nine years in the ground, is apparently answering every expectation of a long life, with the possibility of comparatively easy repair as occasion from time to time may demand.

The department has accumulated a surplus of approximately $140,000, which has been expended in extensions of the plant. This surplus was accumulated in the face of a reduction of the rates by one-half and a saving to water consumers in nine years of municipal service of over a half million dollars.

The topography of Duluth is peculiar in that very unusual heights of elevation are to be supplied. The main plant and reservoir system aims to supply all territory up to 290 feet above lake level. A secondary system, called the hillside system, is being installed which will supply an additional territory to the height of 550 feet above the lake level, and will require a repumping from the reservoirs. A still higher system, called the Hunter's Park system, and supplying a suburban residence section of the community, has also been installed. This system supplies territory to a height of 700 feet and requires a second repumping.

To sum up, Duluth, under municipal management, has developed a water and gas system second to none in the country as to plan, efficiency and substantial results. It would well repay any student of municipal economics to give the municipal plants of Duluth and their record a personal investigation.